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Title: Additive Manufacturing of Glass Structures

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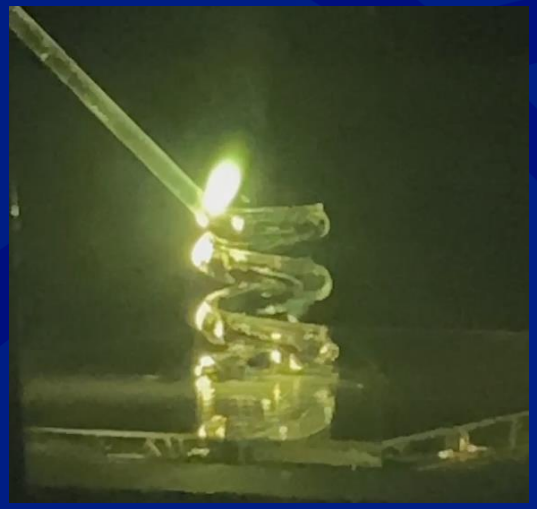
# Additive Manufacturing of Glass Structures



Group: E-1
Presenters: Douglas Meredith, Andre Bos
Mentors: John Bernardin, Ryan Holguin, Alexander Rose

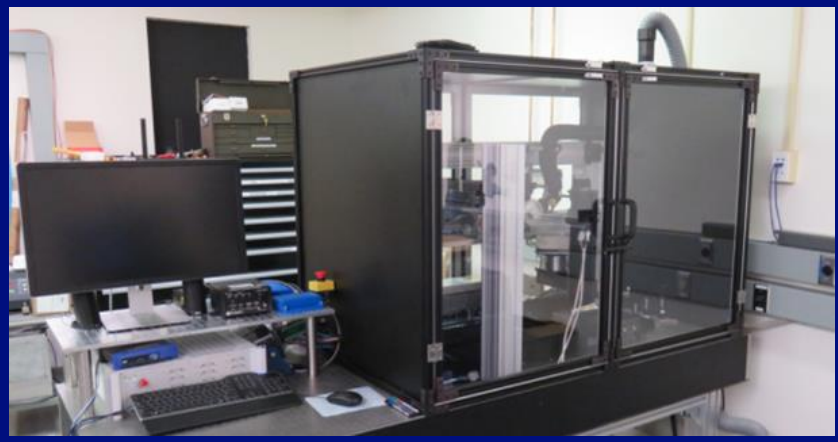
08/04/21

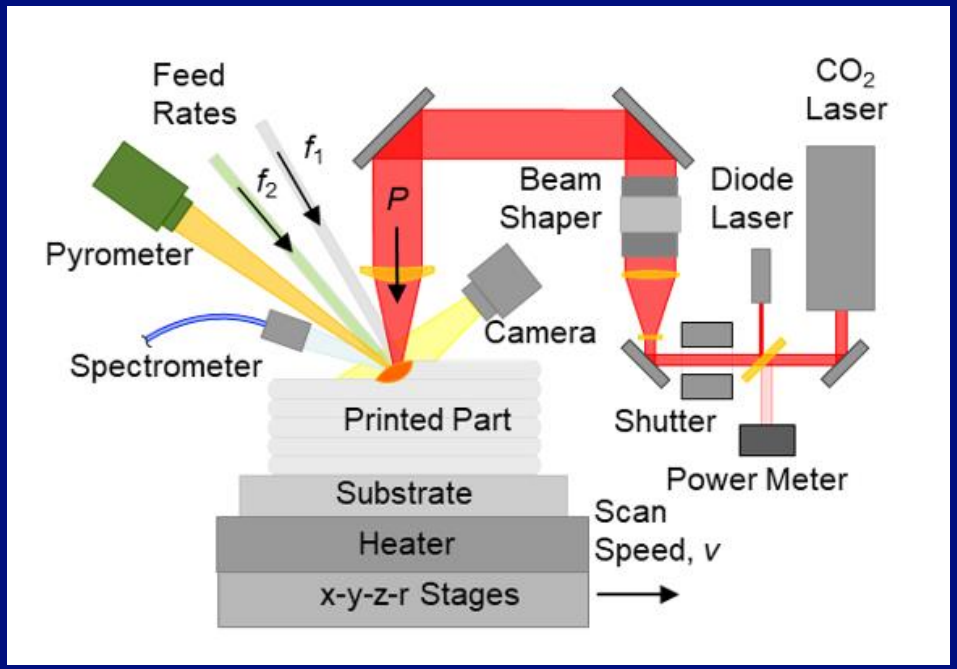
# Outline

1. Machine Setup
2. Glass Properties
3. Opportunities in Glass Additive Manufacturing
4. Control Systems
5. Process Monitoring
6. Current Progress
7. Optimizing Parameters

# Machine Setup

- Fully Enclosed Class IV Laser Cabinet
- 140 W $CO_2$ Laser, 10600nm.
- 4 Axis Build-plate (3 Axis Plus Rotation). 100mm x 100mm x 80mm Build Volume
- Borosilicate and Soda Lime Printing

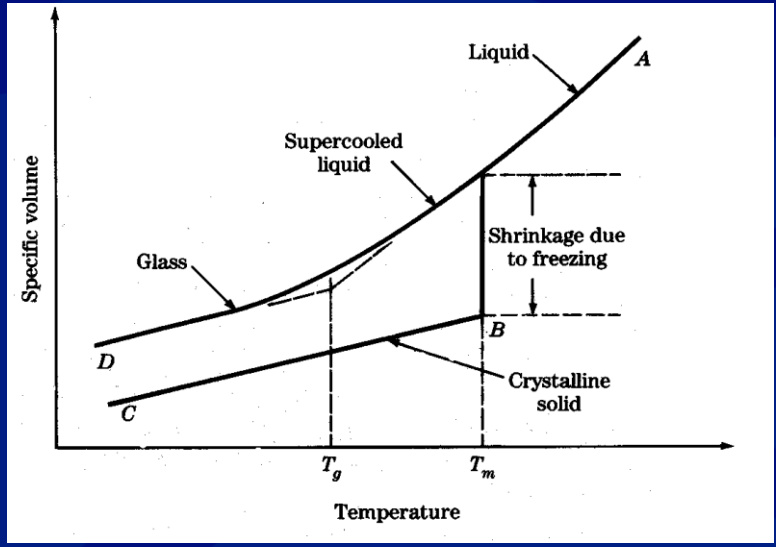




# Glass Properties

## Unique Properties

- Amorphous
- No distinct liquidus transition
- Optically transparent to most wavelengths
- Chemically resistant
- In-expensive feedstock
- Processed in air




[1]

[2]

## Main Disadvantages

- Poor ductility
- Weak to thermal stress and shock from high temperature gradients
- Low thermal conductivity
- Brittle failure mode

# Opportunities in Glass Additive Manufacturing

- Custom chemical processing equipment
- Optical elements
- Fiber optics
- Embedded sensing elements and communications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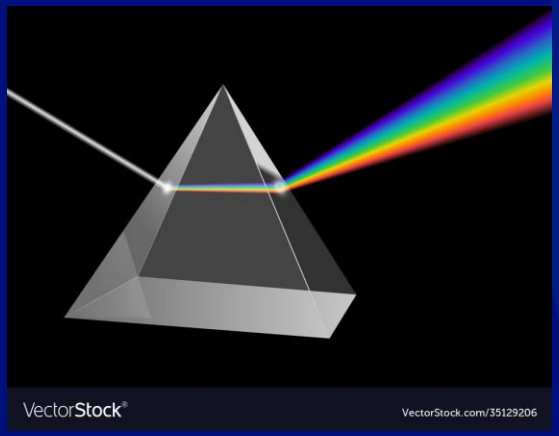


[3]


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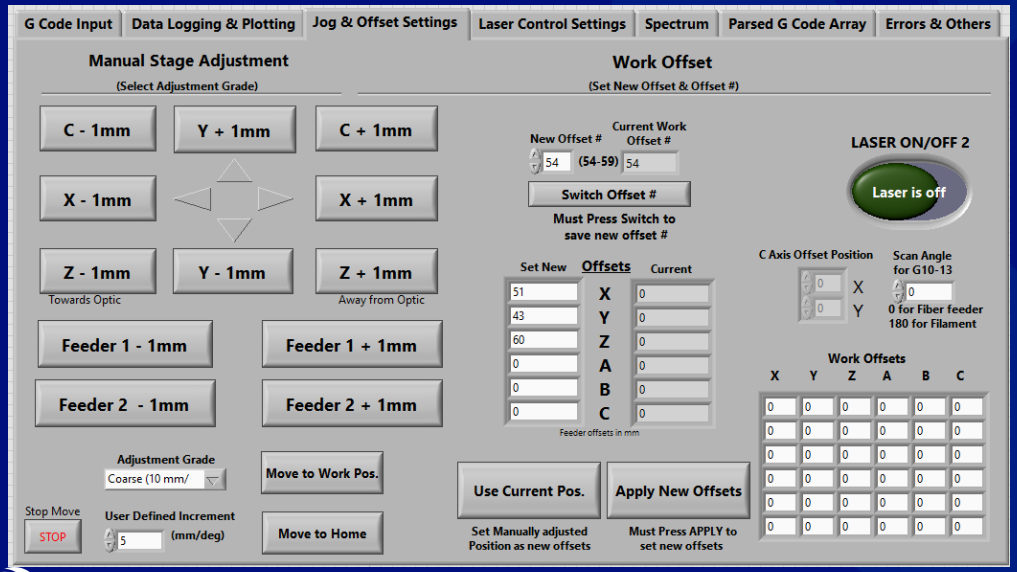
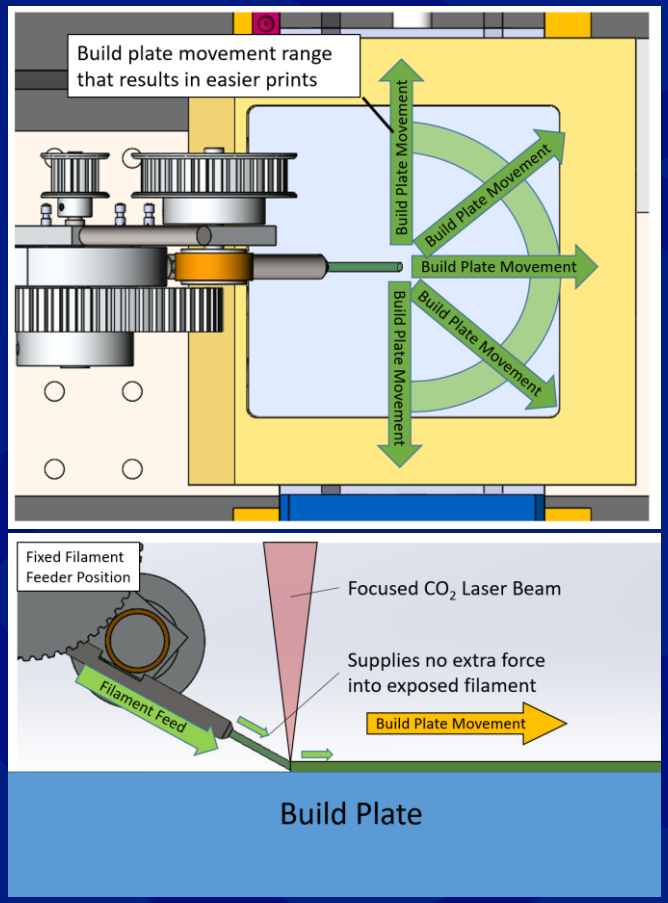
# Control Systems

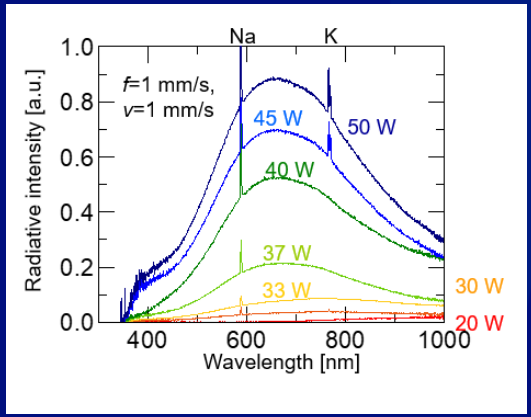
- LabVIEW VI utilizes custom G-code to program machine tool paths and laser sequences
- Active spectrograph and pyrometer data feed
- Movement of build-plate must pull or side-feed glass into molten pool

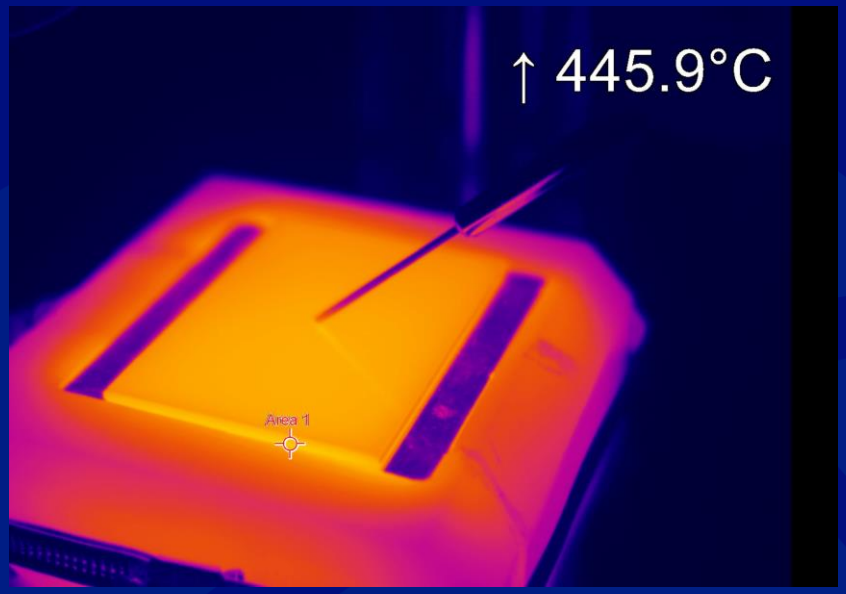


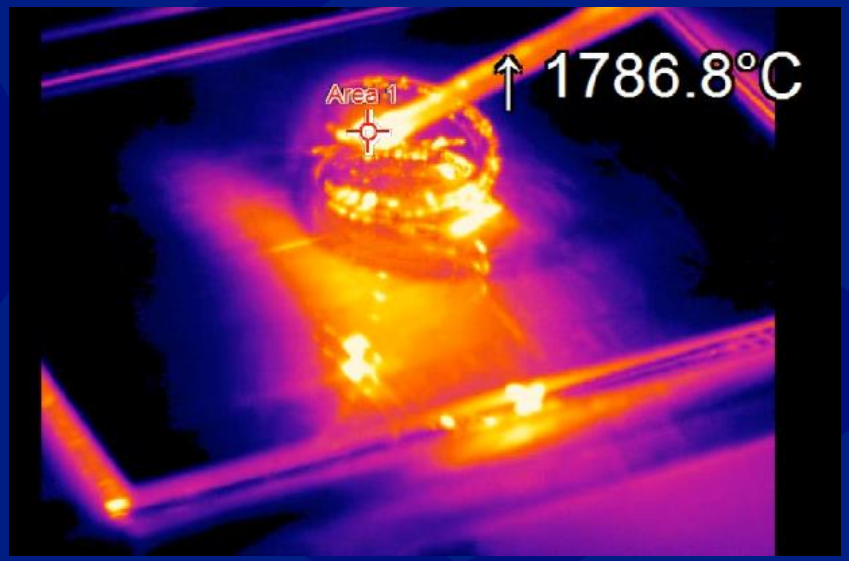



# Process Monitoring

- Pyrometer
  - Measures temperature at build location
- Thermal cameras
  - Monitor build plate temperature
  - Monitor build hot spot during printing
- Spectrometer
  - Emission spectrum of the process
- Power meter
  - Measures the laser power

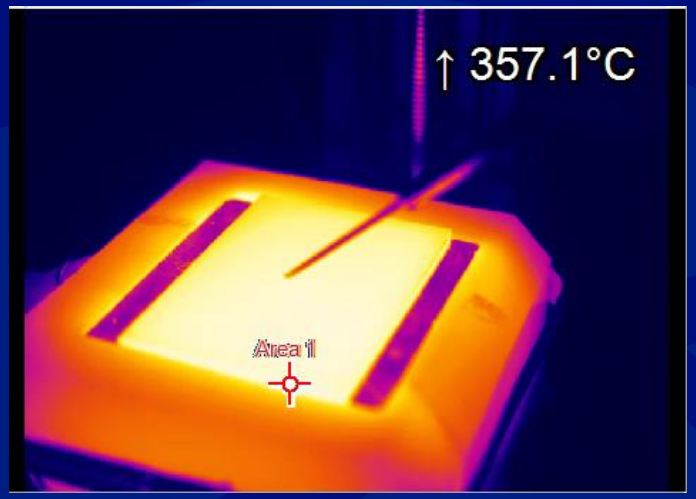


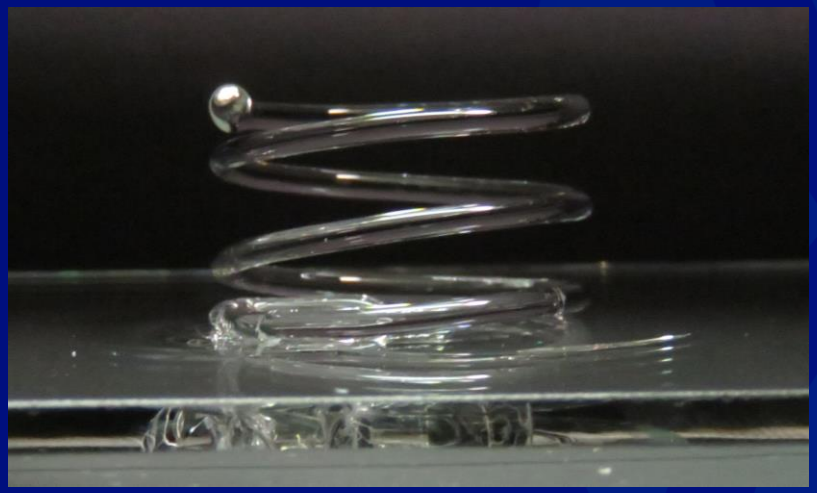



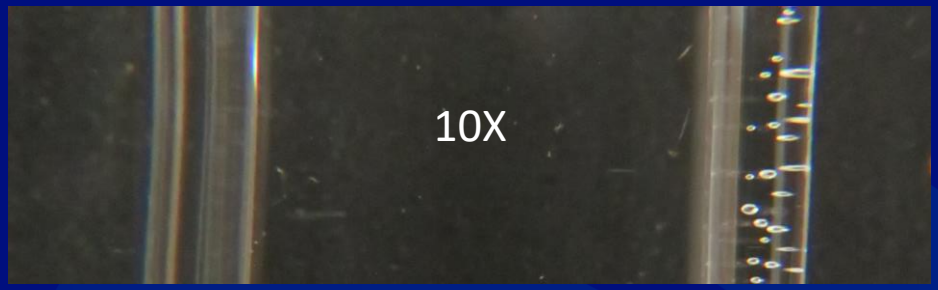
# Current Progress

- Current Capabilities
  - Single wall beads in Cartesian and circular profiles
  - Up to 5 layer walls
  - Helical spirals
  - Basic lattices



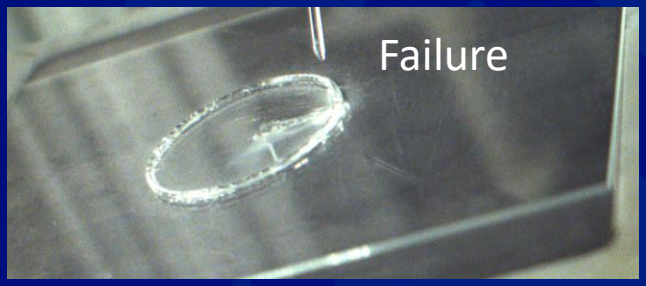



# Optimizing parameters



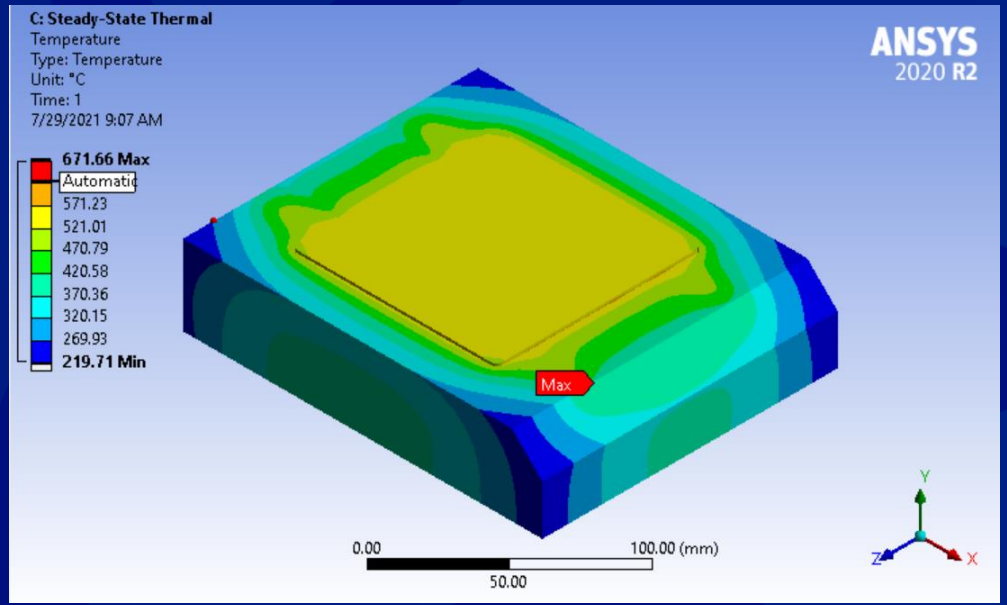

- Failure Criteria
  - Internal porosity
  - Significant build-plate cracking
  - Detachment from build-plate
- Success
  - Optically clear
  - No significant defects
  - Adherence to build-plate
  - Good bead morphology






# Ongoing Research

- Thermal modeling of glass deposition
- Custom feedstock development
- Printed optics design and characterization testing
- Feedback control systems
- Fiber optics printing



# Acknowledgements

**LANL E-1 Team:**

- John Bernardin
- Alexander Rose
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- Professor Ed Kinzel
- Nicolas Capps

# Questions

# References


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Luo, J., Gilbert, L. J., Qu, C., Landers, R. G., Bristow, D. A., & Kinzel, E. C. (2017). Additive Manufacturing of Transparent Soda-Lime Glass Using a Filament-Fed Process. *Journal of Manufacturing Science and Engineering*, *139*(6). https://doi.org/10.1115/1.4035182